

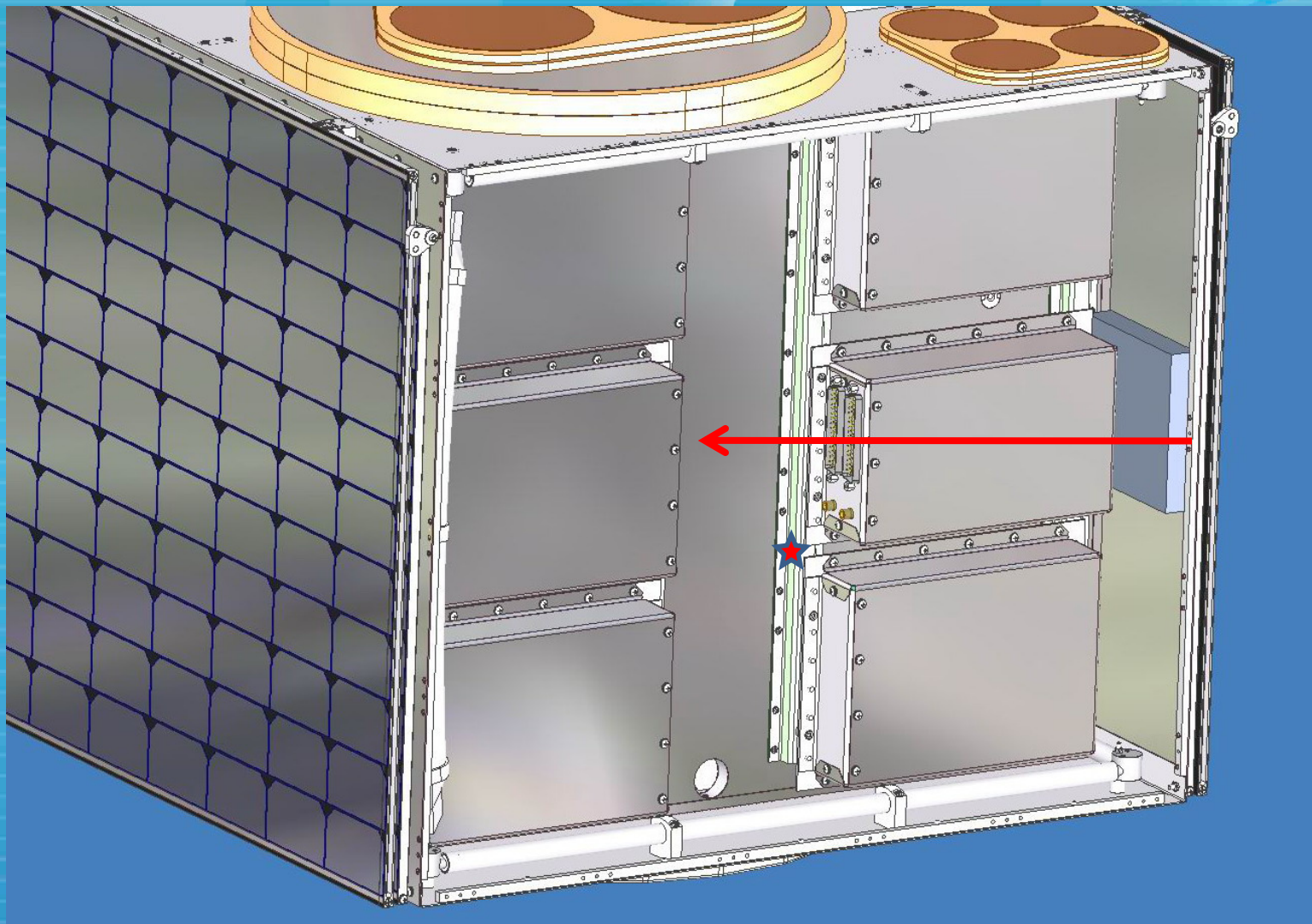
Thermal Design of Eagle Modules



Module Bay of Eagle

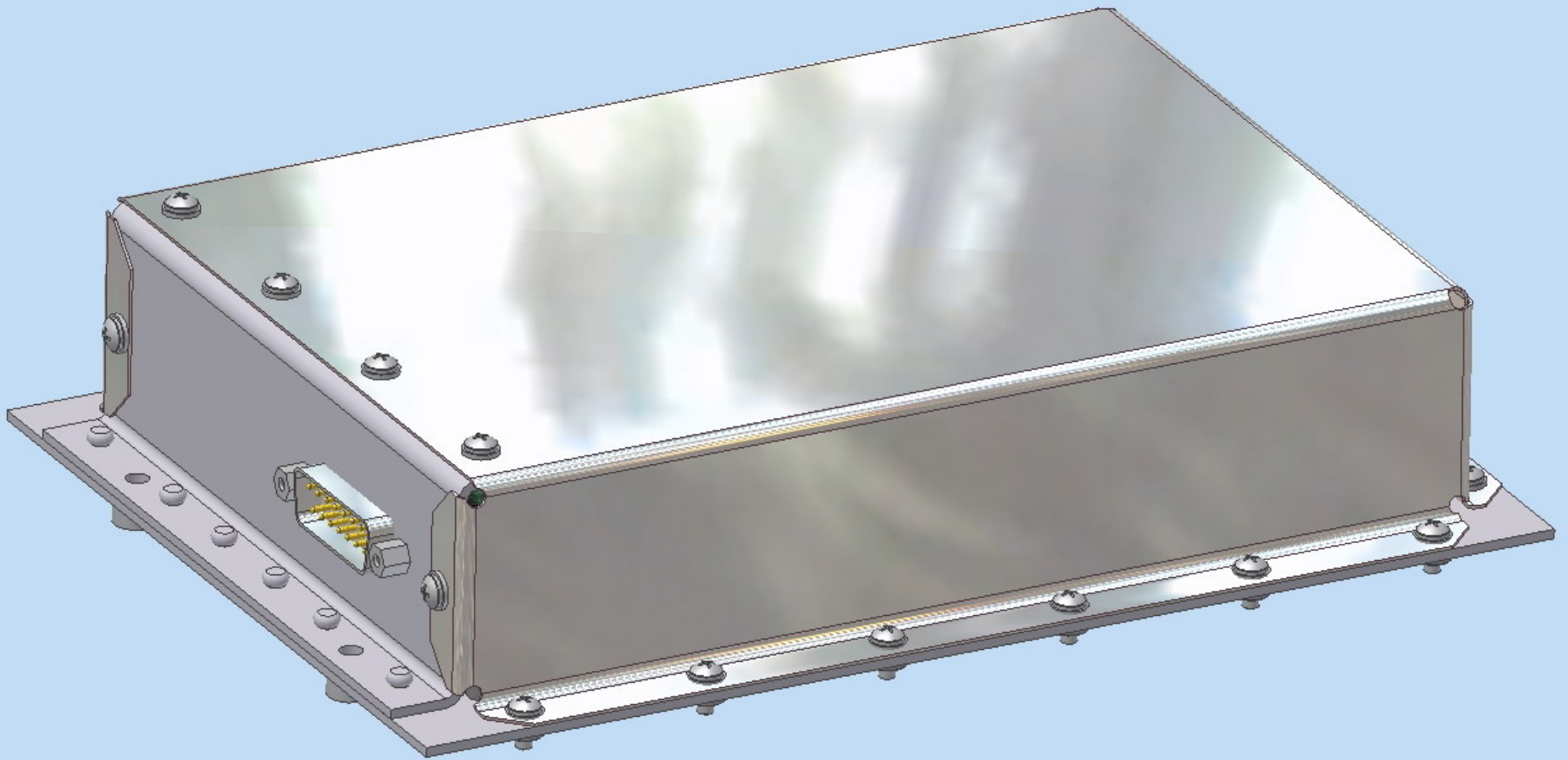
(early design)

Eagle (new) Module Bay Will be Similar Size



Channel

Eagle E05 20 Module

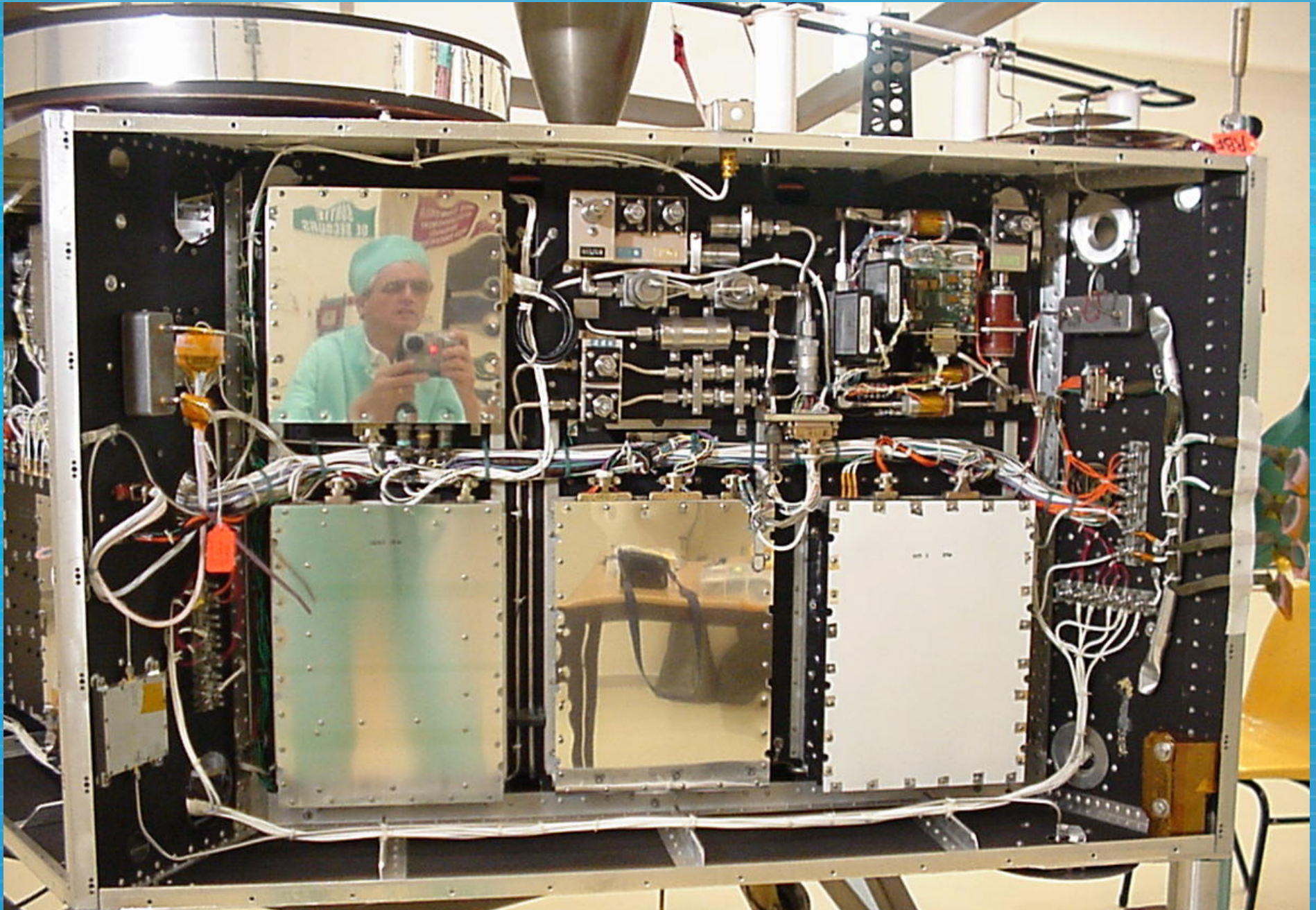


Mean Emittance VS. Allowable Power Dissipation

Module: +20 °C, Spaceframe: 0 °C

Mean Emittance, ϵ	Allowable Power Dissipation
0.04	0.4 W
0.15	1.3 W
0.45	3.9W
0.91	7.9 W

Module Thermal Coatings Are Not New



Power Densities

Solar Heating in Space = 135.4mW/cm^2

Solar Heating on Earth $\approx 94.8\text{mW/cm}^2$
Or considerably less

Power Density of URx Power Section
 $\approx 207\text{mW/cm}^2$

U Receiver PCB Top Layer

Showing Component Areas of Thermal Concern

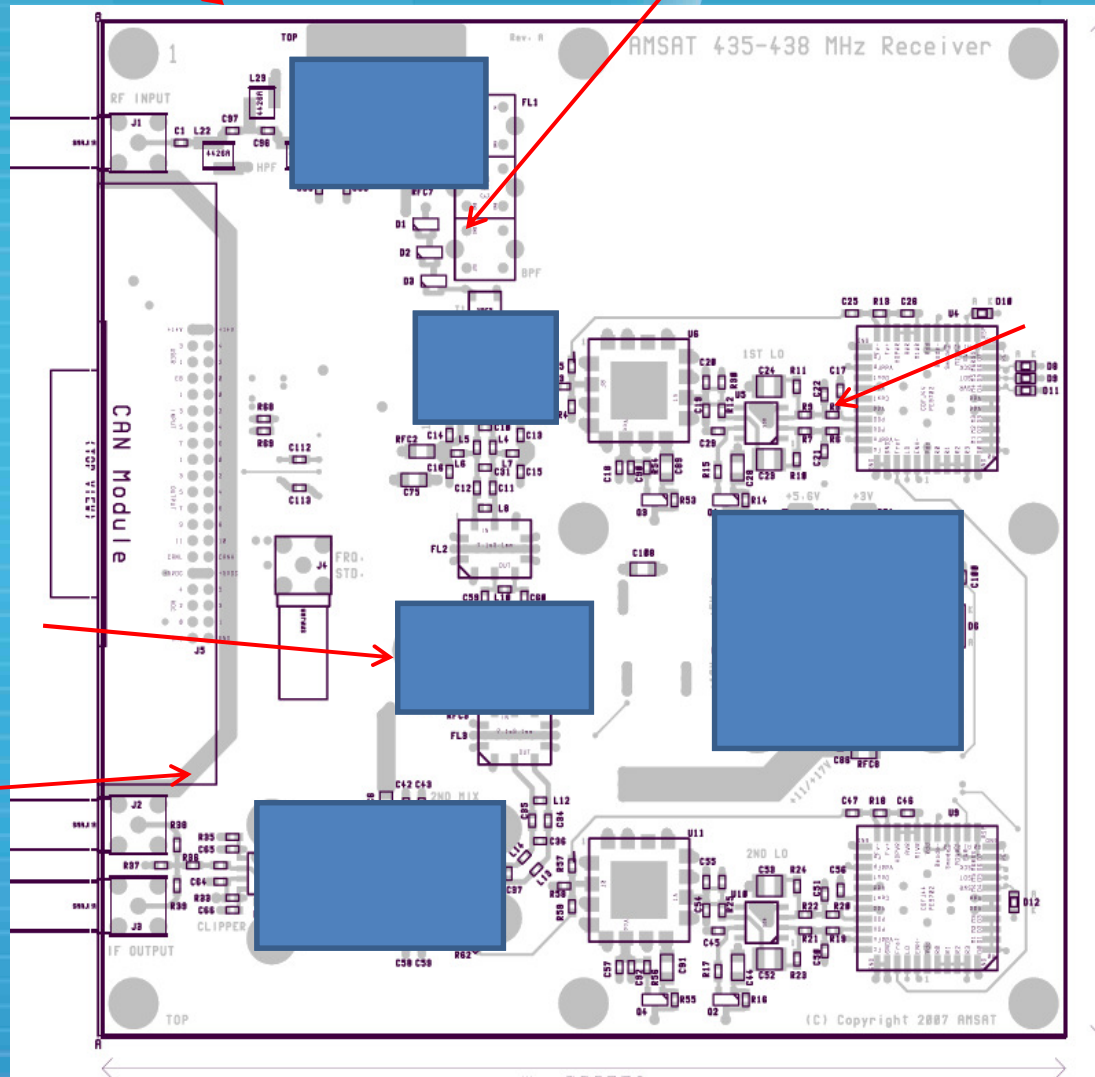
RF Amp. 450mW

1st Mixer 280mW

Power Supplies,
etc., 1284mW

IF Amp. 300mW

2nd Mix., Output
Amp. 670mW



U Receiver PCB Bottom Layer

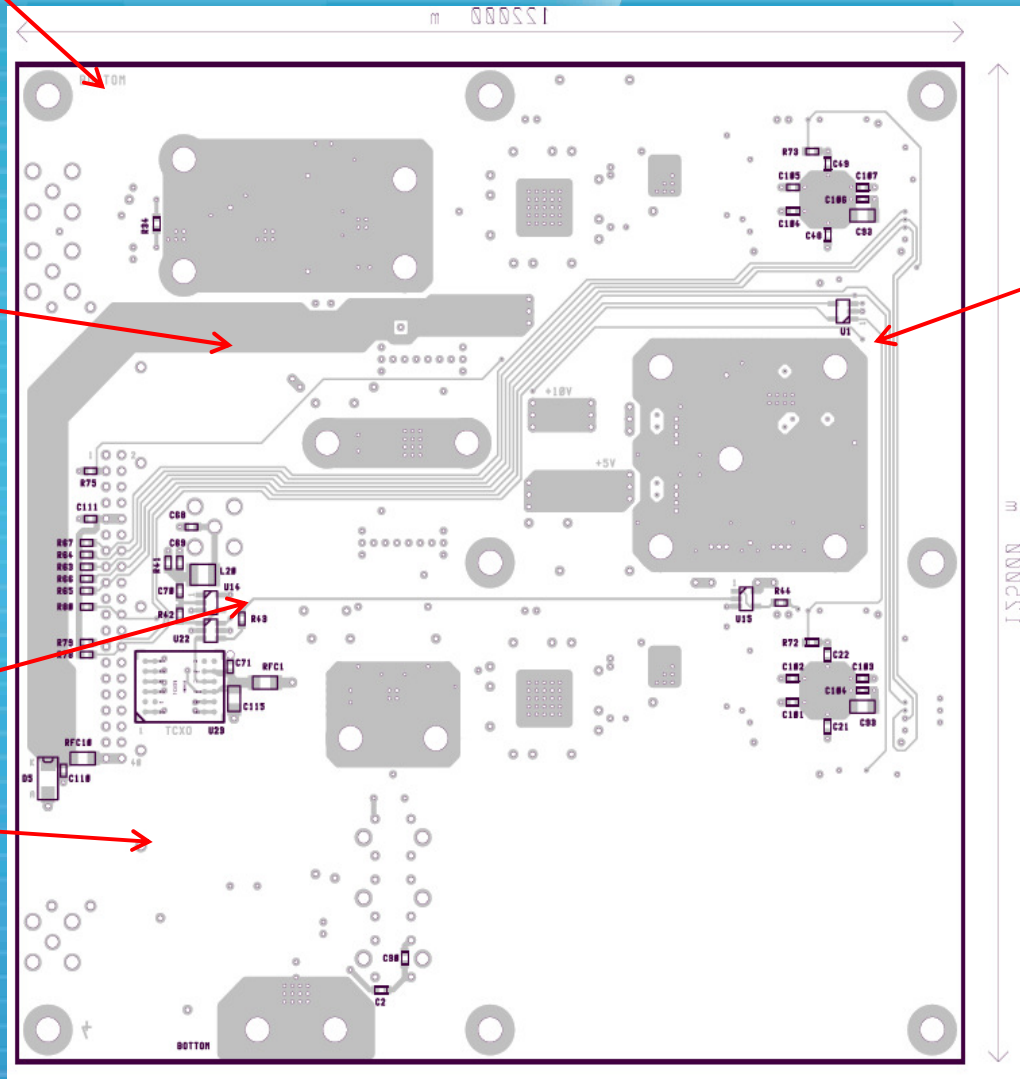
Showing Heat Sink Pads

2nd Mixer &
Output Amp Pad

IF Amp. Pad

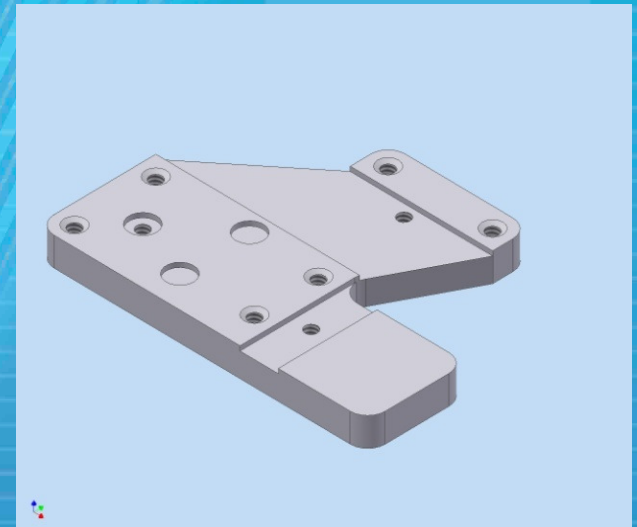
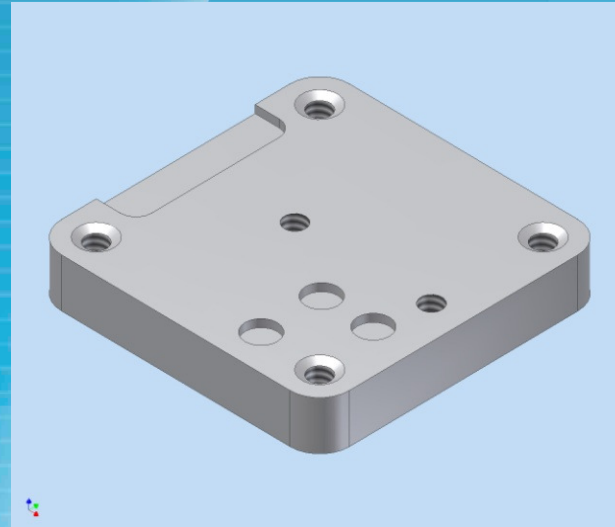
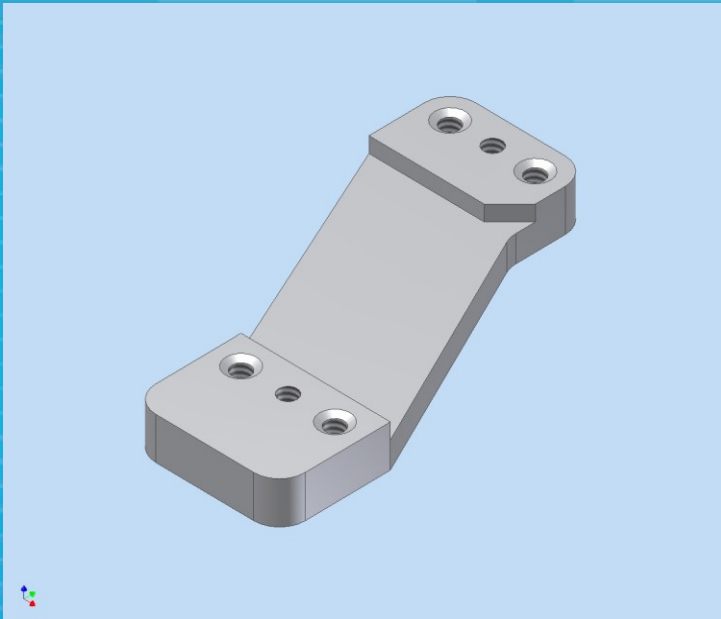
1st Mixer Pad

RF Amplifier Pad



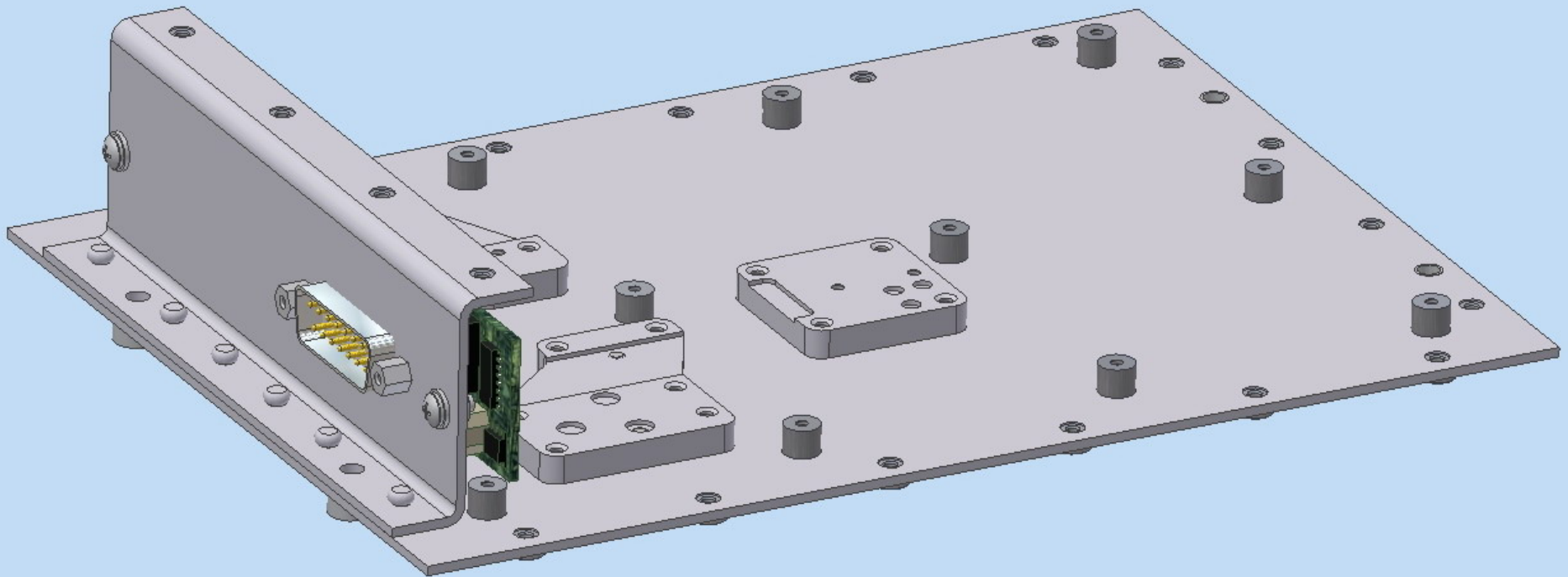
Power Supply Pad

U Receiver Special PCB Heat Sinks



U Band Receiver

E05 20 Module Baseplate With Heat Sinks
Mounted



Eclipse Temperatures

- Eclipse temperatures of AMSAT HEO spacecraft have been of a concern for more than 25 years.
- Early P3 spaceframes were known to be quite cold in eclipse, as seen in AO-10 telemetry, (not currently available).
- Small Eagle thermal analysis shows, in 3 hours of cooling:

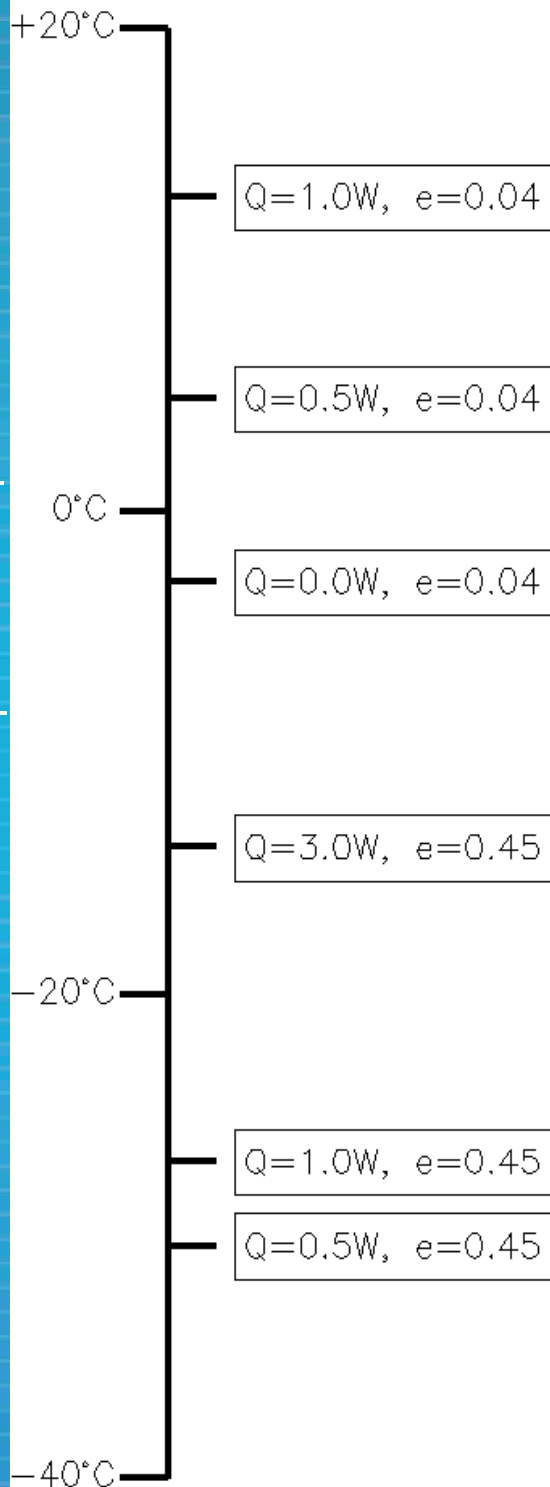
Spaceframe: -26/-45°C

Solar Panels: -81/-125°C

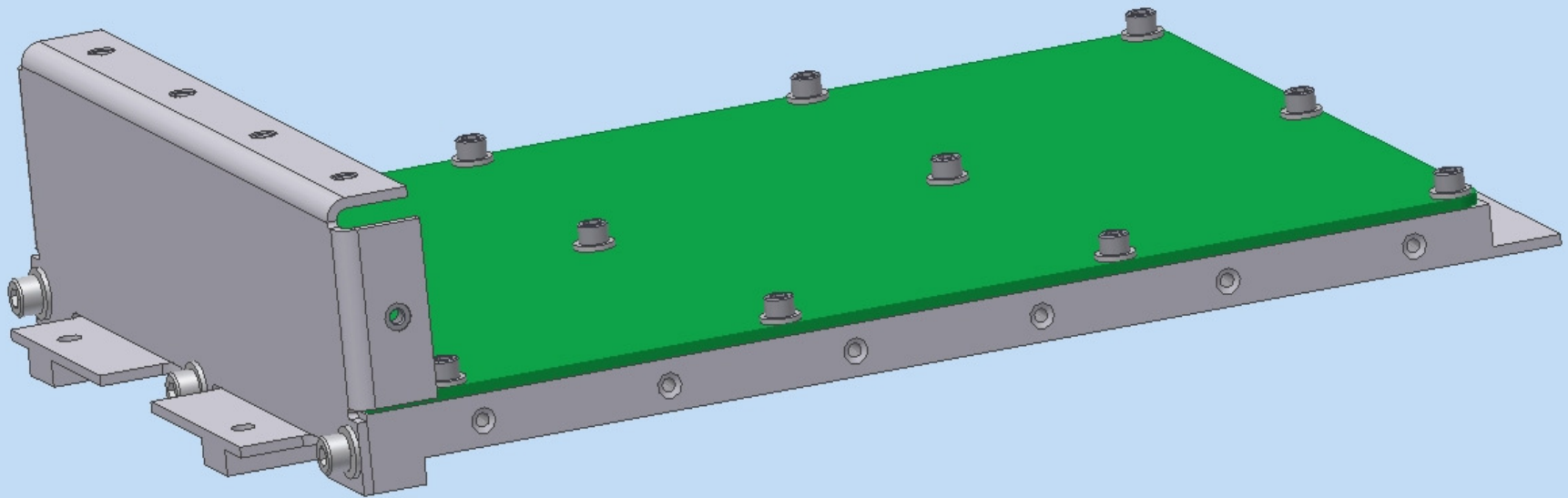
Eagle Module 3 Hour Eclipse Temperatures

Showing effects of
module emittance and
power dissipation

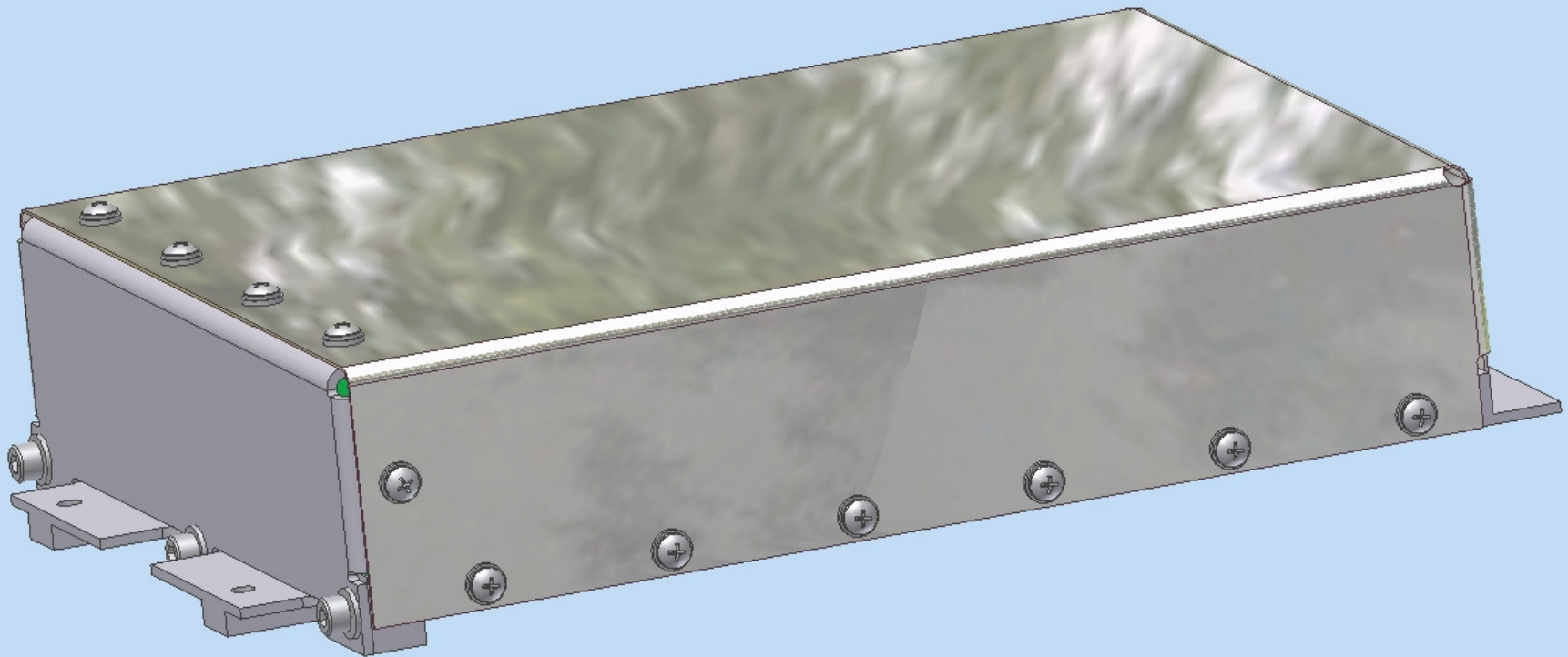
Module Temperatures, °C



A New Module, the E05 60, 140x180 PCB



A New Module, the E05 60, 140x180 PCB



PCB Thermal Analysis Model

